1427

CLINCH RIVER STUDY STEERING COMMITTEE MEETING
4-20&22-60 (Study of Clinch and Tennessee
River Contamination)

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MEMO AVOID ORAL INSTRUCTIONS Date 6/15 1960

To W. L. Richardson

Study of Clinch & Tennessee River Contamination

The attached cover the minutes of the joint meeting held at ORNL recently to review disposal practises with regard to the discharge of radioactive wastes by the Oak Ridge Plants. Also included is the first real exchange of information between ORNL and other local plant groups. This program is now underway with emphasis being directed toward further sampling between ORNL and Chattanooga with the hope that such passes can be completed by the end of summer. As may be noted, samples are rather meager and wide spread. Pls return for file.

Signed

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Minutes & data attached.

AGENDA

CLINCH RIVER STUDY STEERING COMMITTEE MEETING

April 21-22, 1960

Time	Title and Speaker
Thursday, April 21 - Building 2001	
9:00	"Radioactive Releases from ORGDP" -- H. F. Henry, Oak Ridge Gaseous Diffusion Plant
10:00	"Clinch River Studies" -- A. G. Friend, USPHS
11:30	"Studies on Clinch River Fish, Mollusks, Bottom Organisms, and Detritus" -- D. J. Nelson, ORNL
12:30	LUNCH
2:00	"Sediment Transport in the Clinch River and Discrimination Factors" -- F. L. Parker, ORNL
2:30	"Affinity of Clinch River Sediments for Radioactive Nuclides" -- T. Tamura, ORNL
3:00	Executive Session
Friday, April 22 - Building 3504	
9:00	Executive Session (if necessary)
12:00	LUNCH
	Optional -- 4500 Auditorium
1:00	"Public Reaction to Houston's Kellogg Incident and Atomic Waste Fears" -- R. S. O'Leary, Houston Post

MINUTES

OPEN MEETING - CLINCH RIVER STUDY STEERING COMMITTEE

OAK RIDGE NATIONAL LABORATORY

Building 2001 - Conference Room

April 21, 1960

ATTENDANCE

COMMITTEE MEMBERS

Present:

E. G. Struxness, Chairman (ORNL)
A. G. Friend (USPHS)
F. E. Gartrell (TVA)*
R. G. Godfrey (USGS)
S. Leary Jones (Tenn. SDPH & Str. Pol. Control Bd.)
J. A. Lieberman (USAEC - Wash., ex officio)
Vincent Schultz (USAEC - Wash., ex officio, vice I. E. Wallen)
A. A. Schoen (USAEC - ORO, ex officio)

Absent:

F. C. Durand (Tenn. Game & Fish Commission)

VISITORS AND STAFF PRESENT

S. I. Auerbach (ORNL)
W. G. Belter (USAEC - Wash.)
G. Bruscia (ORNL - temporary, Italy)*
Milo A. Churchill (TVA)
C. Henderson (USPHS)
Hugh F. Henry (ORGDP)
M. Howell (USPHS)
W. H. Jordan (ORNL)*
W. H. Martin (Tenn. SDPH)
Roy J. Morton (ORNL)
D. J. Nelson (ORNL)
F. L. Parker (ORNL)
R. M. Richardson (USGS - ORNL)
N. B. Schultz (ORGDP)
C. S. Shoup (USAEC - ORO)*
A. Sorathesn (ORNL - temporary, Thailand)*
A. H. Story (USPHS)
T. Tamura (ORNL)*

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*Attended afternoon session only.

The meeting was called to order at 9:30 a.m. by the chairman, E. G. Struxness. The Chairman welcomed members of the group and expressed appreciation to those who had traveled to the Laboratory to attend the meeting. After announcements regarding certain details of arrangements, he called attention to the agenda which was to be followed (see attached). He said it was expected that both the open session and the executive meeting of the Committee could be completed today, but that in any event business of the Committee would be concluded by noon, April 22.

Dr. Hugh F. Henry of the Oak Ridge Gaseous Diffusion Plant (ORGDP) had been invited to meet with the Committee and discuss radioactive releases from ORGDP.

Dr. Henry distributed a sketch map of the general ORGDP Area (see News Release, 4/18/60, attached), and pointed out the sampling stations on Poplar Creek and the Clinch River. The principal radioactive material handled at this plant is uranium, which is primarily an alpha emitter with beta-gamma-emitting daughters. In general, the equilibrium beta-gamma fields are the maxima attained. However, the daughters of uranium are not volatile and remain behind in the process after uranium is volatilized as UF_6, with higher resultant fields. Small amounts of fission products come from handling of spent fuel from reactors which has been decontaminated in fuel reprocessing but contains some fission products. It was noted that from the nature of the operation, discharges of radioactive materials at this plant are not comparable with those from operations dealing primarily with irradiated reactor fuels and fission product materials. Losses of uranium are kept to a minimum, the standard limit being less than 1 ppm uranium in waste water.

The principal discharge of waste water is through a storm sewer, the location of which was pointed out. Some waste water is accumulated in a holding pond from which it flows to Poplar Creek. Asked about release of U^{235}, Dr. Henry said that the specific activity of enriched uranium is higher than normal uranium which enables checking of the waste water. Essentially no U^{235} is released, and the counts from uranium in the waste are due to U^{238}. Asked about Ra^{226}, Dr. Henry replied there was no indication that this was above background. A control concept used is to control the uranium and maintain the low specified limits with the result that the daughter products will also be taken care of.

With regard to sampling, continuous composite liquid samples are taken in Poplar Creek and the Clinch River as indicated on the attached map (see News Release, 4/18/60); in addition at the water plant (potable) there is a continuous sampler for analysis of the raw water from the Clinch River, this location being about 8 miles below the mouth of the White Oak Creek. Water samples at other points in Poplar Creek and in Clinch River above and below ORGDP are taken periodically as checks. Mud samples are taken periodically; for example, at each of the water sampling sites and at the point of waste discharge a grab sample is taken once per quarter. In the streams no mud sampling dredge or other sampler is used, and mud is taken by dip-sampling, avoiding debris. It was brought out that the continuous water samples are not proportional to stream flow; they are taken at a constant rate continuously.

The results of analyses of water and mud samples during 1959 were reviewed, as tabulated in the attached News Release. Records of the monitoring program go back to about 1949. It was noted that for mud no MPC value is specified. A chart was shown comparing gross beta activity in the raw water at the water plant with the nonoccupational MPC value for Sr^{90} in water for the past several years. Experience, in general, has been that the gross-beta level is around 10% of the MPC based on Sr^{90} alone and much less than that based on the mixture of radioisotopes actually present. Asked about build-up of activity in the mud in a waste holding pond, it was stated that this is checked once a year and that little, if any, activity is released to it now. No data on the results were at hand at this meeting.

The Chairman thanked Dr. Henry and Mr. N. B. Schultz of ORGDP for making this information available to the Committee. There was comment that, in connection with actual work on the river study, there will probably be need to consider specific data or to make field observations concerning conditions in the ORGDP Area or in Poplar Creek above.

The Chairman said that people at the Y-12 area were invited to discuss discharges from that plant, but they requested more time and will discuss this subject at a later meeting.

In the next discussion, A. G. Friend described the work done in February 1960 by personnel of PHS sanitary Engineering Center in Cincinnati. A preliminary report on this work was distributed (copy of report attached to these minutes).

This preliminary survey, made February 9-15, 1960, included collection of samples of water, bottom muds, fish, miscellaneous aquatic fauna, plankton, and filter sand from the Chattanooga Water Treatment Plant. These were taken from seven sampling stations at selected points from above Norris Dam on the Clinch River and at Fort Loudoun Dam on the Tennessee River to Chattanooga. In addition, samples were taken from three different locations on Bear Creek in the Oak Ridge area. A total of 230 analyses of samples or components of the same field sample were made. It was explained that the report has not been finally checked and is in preliminary form in other respects. It is made available for the use of the Committee, but releases or quotations from it should be reserved until it is in more nearly final form.

Friend summarized the survey briefly and, with assistance from Henderson, Howell, and Story, answered questions about it.

In discussing Table 2, Radionuclide Concentration in Water etc., Friend commented that 33 μμc/liter is used as the MPC value for drinking water. White Oak Creek samples showed 2800 + μμc/liter of Sr^{90}; and the trend of concentration was found to decrease downstream, except that it increased from a minimum of 0.4 μμc/liter (background at Fort Loudoun Dam), and 1.5 μμc/liter at Watts Bar Dam, to 4.4 μμc/liter in the raw water at Chattanooga. Jones explained that the Chattanooga figures are based on quarterly composites of weekly samples. He said that the last quarter-year of data for Chattanooga showed in the neighborhood of 1.4 μμc/liter. Schultz (AEC) asked about analytical and counting errors. Friend replied that the concentration of radionuclides is low, but with present methods they can be detected and measured. He commented that the Chattanooga Water Treatment Plant is estimated to remove about 18% of the Sr^{90}. Lieberman asked why the increase as you go downstream; for example, is activity desorbed from the mud back into solution? Friend said he did not know. Struxness said there are indications that the Sr^{90} is in solution - only 18% removal at Chattanooga Water Plant. Also, a recent review at ORNL of data on White Oak Lake Bed indicates transport of strontium in solution, while cesium is transported on the sediments. Schultz asked whether the PHS will assign confidence limits to the data? Friend said, yes. Parker commented that the results of sampling in White Oak Creek and downstream should be correlated as to relative times of sampling and time of water flow - "may be sampling different water" than that analyzed from White Oak Creek.

Friend summarized the data on analyses of mud samples. These also showed higher concentrations at Chattanooga. Those below Watts Bar Dam were low - samples may not have been very good because of scouring below the dam.

Friend showed a series of charts of results of analyses of fish taken at seven locations. Henderson commented on the data in Table 5, Table 6, Table 7, etc. Friend said that in most cases the activity was from natural sources. He said some small fish were taken from Norris Reservoir, but there is no table in the report showing these data. Fish from White Oak Lake, about 6 inches long, 51 in number, are covered in Table 9. Schultz asked whether the intestinal contents were separated. Henderson replied that the whole alimentary tract was removed (separated). All other viscera were left to be assayed with the flesh, bones, and scales. Lieberman asked what the trend of activity in fish was as collection was farther downstream. Henderson replied that the picture is not very clear, but bottom feeders are picking up radioactive materials, as shown, for example, in Table 19. He emphasized, however, that we cannot attach too much importance to one series of fish samples.

Friend commented on the tests of filter sand from the Chattanooga Water Plant, shown in Table 23.

Struxness reminded the group that this first round of sampling was expected to serve as a basis for more definite planning; that is, develop a better pattern of sampling. He asked what conclusions had been reached regarding this. Friend and Henderson pointed out that the data had not been analyzed and studied fully. Lieberman pressed the point that opinions and observations should be recorded, and purposely we should add to or change plans for both sampling and analyses.

After a short intermission, the Chairman called upon D. J. Nelson to discuss "Studies on Clinch River Fish, Mollusks, Bottom Organisms, and Detritus." He distributed a brief report, "Cooperative Fish Studies by ORNL and TVA - March 23 to April 1, 1960," (see report attached) and a one-page attachment, dated April 13, 1960.

Nelson reviewed the results of the fish study shown in the tables. He said the data do suggest that activity in fish from the Clinch River is slightly higher than in those from Douglas Reservoir. Schultz (AEC) discussed sampling errors, especially sampling variations, and commented that variations may be one to three orders of magnitude. Nelson thought this too much and that one order of magnitude more reasonable if care is used in sampling. There was general discussion of sampling errors. It was asked whether controlled exposures of fish, for example, in a cage, might be feasible. Nelson said that controlled laboratory experiments would be more reliable, but we are not set up to do this here. Such work is being done at Hanford and by the PHS. Lieberman thought we must get (as a frame of reference) data on certain questions; for example, rate of uptake, differences in species, size, etc., and fish movement. It was agreed that studies of this kind should be made for the Clinch-Tennessee River system. Also, a review of literature on fish movement and the reports of TVA studies on these rivers should be done.

Nelson indicated on a map the extent of studies of bottom organisms made and planned. He commented, "In the river bottom we have a tremendous reservoir of organic matter" - much leaf material provides organic matter; also, leaves with relatively high radioactivity have been found. Schultz (AEC) inquired whether there will be enough radioactivity in aquatic organisms for radiochemical analysis. Nelson thought there will be no trouble except for the laborious job of separating the organisms. Auerbach commented that from ORNL operations leaves are contaminated and get into the river. Therefore, sampling of water alone misses leaf transport to the stream and suggests that we must look at leaves and leaf material on the bottom of the stream. Nelson said that some clam and mussel shells from Indian mounds of the same species as in the river now have been obtained; and that Ca-Sr ratios are being determined in these shells, those from the river, and human bones.

Nelson mentioned a planned study to determine movement of radionuclides by bottom organisms. Lieberman raised the question of the importance of biological transport as compared with direct transport by the water in solution. There was no answer to this question. Henderson asked whether the river inventory is a continuing study. The answer was that it is the initial inventory of the Clinch River system and after this we will be concerned with the income and outgo of radioactive materials and their route in the River.

Struxness asked what is now indicated for a plan of future work. In his reply Nelson outlined what we would like to study: (1) fish movements in the river, (2) bottom organisms, and (3) molluscan data that are of interest (at least to us in this survey).

The meeting was recessed for lunch at 12:25 p.m.

Afternoon Session

Reconvening the meeting at 1:30 p.m. the Chairman called on F. L. Parker who discussed "Sediment Transport in the Clinch River and Discrimination Factors."

Parker summarized on the blackboard data regarding sediment in parts per million moving past the mouth of White Oak Creek and also an estimate of pounds per year for the 5-year period, 1955-59. He also listed the percentages of radioactivity on the silt in the composite samples collected at Center's Ferry, which were analyzed for Co^{60}, $Zr\text{-}Nb^{95}$, Cs^{137}, Ru^{106}, Ce^{144}, and Sr^{90}. These percentages varied from 5%

for strontium to 67% for cesium. The percentage distribution of the radionuclides from Center's Ferry analyses were listed and also the activity in curies. The distribution of activity according to season for 2 years of the period was shown.

Note: Further details of the data presented by Parker are given in the tables attached at the back of these minutes, "Sediment Transport and Related Data."

The bed load was discussed by Churchill, Lieberman, and others. Although determinations of transport are not adequate, it appeared to be the consensus that the bed load is not an important factor. Churchill said that in his opinion bed-load measurements should not be done because: (1) bed load is not very significant in transport of radioactivity, and (2) such determinations are very complex and difficult to make.

T. Tamura of ORNL discussed "Affinity of Clinch River Sediments for Radioactive Nuclides." He acknowledged that the work reported was done at ORNL by Aroon Sorathesn of Thailand and Guiseppe Bruscia of Italy, whom he introduced to the Committee.

Tamura distributed Table IV, V, VI, and VII (see tables attached). He explained that the studies were made using the jar-test technique and that the four tables being discussed were from the report on the entire study submitted by Sorathesn and Bruscia.

This was primarily a study of the characteristics and sorptive properties of uncontaminated sediments collected from the bottom of Clinch River. For comparison tests were run concurrently on the standard clays - illite, kaolinite, montmorillonite, and vermiculite, as shown in the tables. The process isotopes were Cs^{137}, Co^{60}, Sr^{85}, and $Zr\text{-}Nb^{95}$. Schultz asked about the mechanism of sorption to explain time dependency shown by data in the tables. Tamura discussed at some length the structural properties of the clays and the mechanism of sorption that predominates. Friend asked about chemical conditions, techniques, etc. Tamura explained these and commented that further details would be available in the report when it is completed and released.

Lieberman inquired what differences would be expected if river water had been used in the experiments instead of distilled water. Tamura said very little except slight reduction in the sorption of strontium because calcium in the river water would make the K_d lower.

Struxness asked Parker and Tamura what the preliminary study has shown. In reply they noted: (1) variability in sediment and concentration after heavy rains suggest that in the Clinch River Study we must be sure to sample after rains rather than strictly on a time basis; and (2) a smaller percentage of activity than was expected was found to be associated with the sediments which suggest the need for more sampling and analysis for dissolved activity in the water.

The Chairman invited reports by anyone present of changes in situation with respect to money, manpower, etc., but there were no reports. Lieberman commented that budget hearings are in progress.

There being no further business the open meeting was adjourned at 2:30 p.m. Members of the Committee were requested to be available for the executive session at 2:45 p.m.

ATTACHMENTS

1. Agenda, Steering Committee Meeting, 4/21/60
2. Objectives of Clinch River Study
3. News Release - Environmental Sampling, ORGDP, 4/18/60
4. Preliminary Report - Samples by PHS, February 1960
5. Fish Studies, ORNL and TVA, 3/23-4/1/60
6. Sediment Transport and Related Data by F. L. Parker
7. Percentages of cesium, cobalt, strontium, and zirconium-niobium sorbed by clays - 4 tables

Minutes prepared by Roy J. Morton

MINUTES
EXECUTIVE MEETING - CLINCH RIVER STUDY STEERING COMMITTEE
OAK RIDGE NATIONAL LABORATORY
Building 2001 - Conference Room
April 21, 1960

The Executive Session was convened by the chairman, E. G. Struxness, at 2:45 p.m., with the following members present: W. G. Belter (ex officio), A. G. Friend, F. E. Gartrell, R. G. Godfrey, S. Leary Jones, J. A. Lieberman (ex officio), Vincent Schultz (ex officio, vice I. E. Wallen), and A. A. Schoen (ex officio). Member F. C. Durand was absent. Roy J. Morton attended to serve as secretary.

The Chairman raised the question of what should be done with the preliminary reports presented in the open meeting earlier today. After discussion it was agreed that copies of the preliminary reports should be attached to the minutes of the open meeting with the notation that they were of a preliminary nature, distributed for the use of the Committee with the understanding that the material is not to be released or quoted openly without approval from the agency that prepared the report. Schultz commended the several individuals who did the preliminary work and those who presented the reports at the open meeting.

Several members of the Committee requested extra copies of the minutes for use by members of their staff. It was agreed that these should be provided, and the secretary made note of the extra copies requested.

Struxness inquired as to the status of the press release on the Clinch River Study which was submitted sometime ago. Lieberman stated that this release had been reviewed and some revisions made by the AEC in Washington and that the final version should now be enroute from the Washington office to AEC-ORO. There were comments from members of the Committee who had received the original draft of the release. Gartrell received a copy. Friend said that PHS in Cincinnati and Washington received copies; some individuals of PHS in Washington thought that public health was not emphasized sufficiently. Lieberman said that some in the AEC felt that the release as drafted left the implication that this was the first time anything has been done on the Clinch River. The AEC Public Information people in revising the draft wanted to make it clear that this is a research study; monitoring already is being done.

Jones said he had heard that a writer in Washington is anxious to write an article on releases of radioactivity at Oak Ridge. After discussion, it was the consensus of the Committee that it is desirable to get out the release on the Clinch River Study to forestall irresponsible releases about the river.

Struxness asked for discussion of something that may be a problem; namely, some biologists feel that this is just another stream pollution survey. Schultz said he saw no objection to the type of data being collected. He has talked with Friend and Auerbach about it. Different groups have different interests, and their work will not be of identical character. With respect to monitoring functions, Lieberman emphasized that this Committee should not approve or disapprove conditions in the river. Other members of the Committee appeared to agree. Lieberman commented further, restating the purposes of the study and that we must have the biologists' help. If they are able at the same time to exploit their own interests, there is no objection. We must aim to be practical to the end that answers will come out of this study, even though this is achieved by survey rather than intensive study techniques. Friend said that PHS is not set up to study particular organisms intensively - must use survey techniques. Jones suggested that the objectives of the study should be restated in or attached to these minutes. This was agreed.

Struxness mentioned a letter of which he had knowledge that tended to discourage support for work on the biological aspects of the study by the Biology and Medicine Division of AEC. Schultz said that he was interested in this comment and that he will inquire into it further.

Lieberman emphasized again that we must get help from other agencies, for example, TVA. Gartrell said that if the Committee will state a particular thing to be done, TVA can probably manage to get it done.

Struxness commented that hydraulics and hydrology were not discussed much in the open meeting. There were a number of suggestions aimed to improve coverage of these aspects. Lieberman asked whether "hydraulic data" is an area in which TVA can co-operate with USGS. At least "could the TVA and the USGS collaborate on: (1) what to be done, and (2) who to do it?" Gartrell said that sampling should be fitted into the hydraulic pattern of the streams. Lieberman asked what do we have to do to establish a working mechanism for co-ordinating sampling and hydraulics? Gartrell suggested detailed discussions between the USGS and the TVA Hydraulic Data Division of which A. S. Fry is head. Gartrell said that he can and will arrange for these discussions. Examples of questions suggested to be discussed were:

(1) Based on the knowledge now available, is it reasonable to set up times when it would be simpler to do various parts of the study?

(2) What is necessary to set up a system of recorded hydraulic data that will aid in guiding other parts of the study?

Struxness suggested that the question of how many gages are needed is a part of this problem. Lieberman made a Motion that by the time of the next meeting Gartrell and Godfrey be asked to study the need for gaging and submit recommendations as to what gages are needed and how the information from them is to be made available. The motion was amended to ask Gartrell and Godfrey to do this within a month, if possible, and report to the chairman of this Committee. The motion was approved.

Schultz cautioned that the sampling program must not be biased by selecting low flows only; it is essential that all conditions be represented. Gartrell said that the "wave" and "slug" behavior is quite complicated as flow is cut on and off at the dams. Lieberman said that he would like to hear this discussed in detail at some meeting of this Committee. There was general discussion, and it was the consensus that we need for TVA not only to provide the flow data but also to help interpret its meaning in terms of this study.

Schultz commented that this type of information (hydraulic) is not so important in sampling of the kind the PHS did in February (mainly survey), but is more important for studies such as Auerbach and Nelson are doing; they are trying to explain "why." There was general discussion of the difficulty of getting definitive ecological knowledge in a highly variable situation. Schultz said that this is true, but we should do the best we can, taking advantage of related information, such as hydraulic data, discussed earlier.

Lieberman mentioned the problem from use of various units and suggested that a small committee be formed to consider what units should be used. Schultz thought that this is too much of a problem to undertake as a part of this study. Struxness suggested that each agency should select and state what units they prefer to use, and these can be converted by other agencies to their own units if necessary.

Friend said that the PHS would like to make another survey sometime in the early summer, for example, June. Struxness said that this is desirable to show seasonal differences. He requested that in the next survey efforts be made to: (1) notify ORNL people in advance and have more discussions, and (2) consider the possibility of splitting samples more systematically than was done in the last survey.

Next Meeting

Thursday and Friday, August 18-19, 1960, were selected as the dates for the next meeting.

The Committee was adjourned at 4:15 p.m.

Minutes prepared by Roy J. Morton.

OBJECTIVES OF CLINCH RIVER STUDY

The purpose of the study of the Clinch River below Oak Ridge National Laboratory is to obtain fundamental information on the physical, chemical, and biological dynamics of a flowing, fresh water ecosystem which is receiving large volumes of low-level radioactive wastes. Information from a broadly conceived fundamental and applied program will have important implications for two major world-wide problems resulting from large-scale environmental contamination. These are:

1. What is the over-all diluent capacity of fresh water environments for an increasing continuous input of large volumes of low-level radioactive wastes?

2. What is the long-term indirect impact of radioactive contamination of such environments?

Objectives

This program has four general objectives, namely:

1. to determine the fate of radioactive materials currently being discharged to the river,

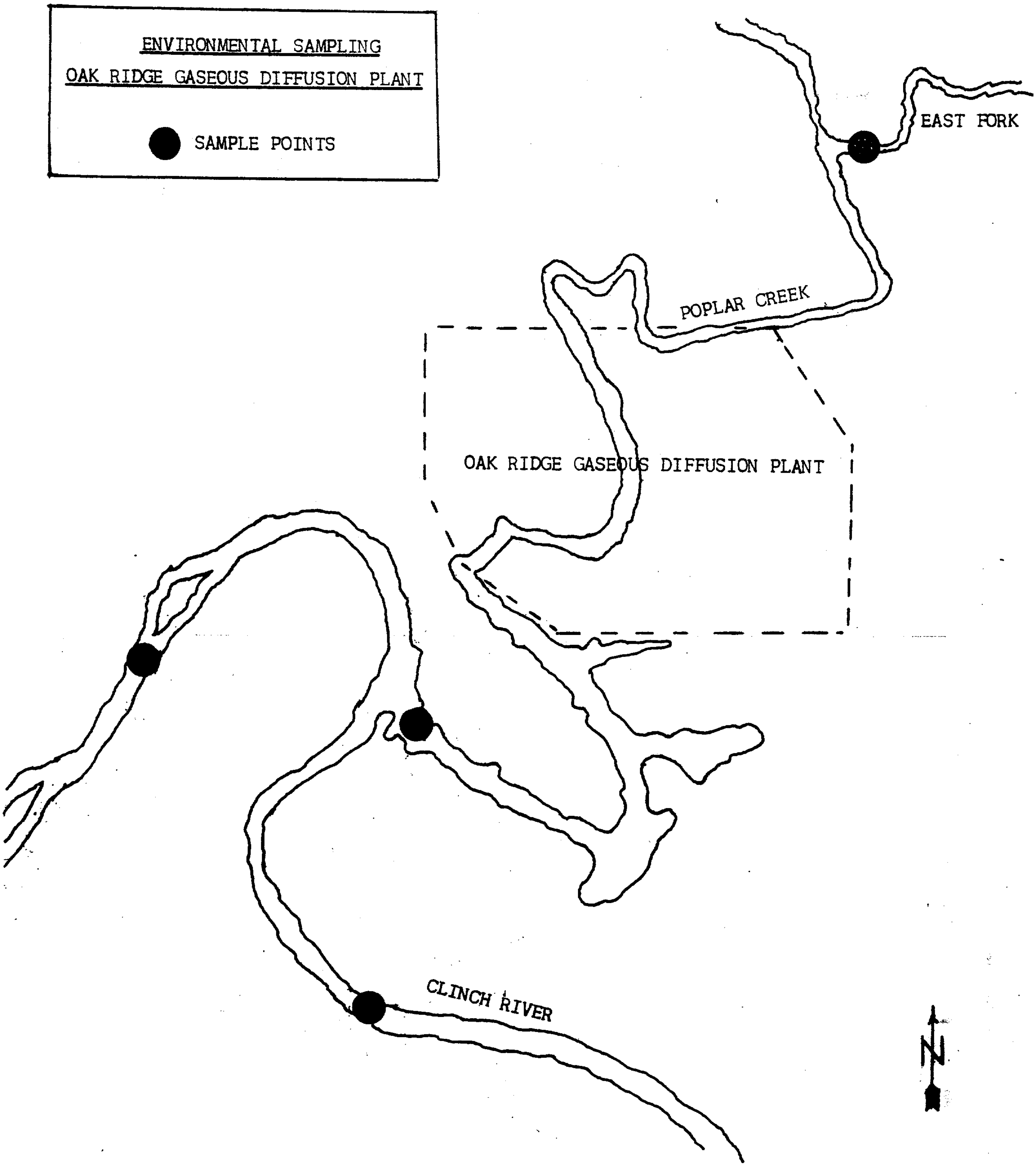
2. to determine and understand the mechanisms of dispersion of radionuclides released to the river,

3. to evaluate the direct and indirect health and hazard aspects of the current disposal practices in the river,

4. to evaluate the over-all usefulness of this and similar rivers for radioactive waste disposal purposes.

News Release

April 18, 1960



ws Release April 18, 1960

ENVIRONMENTAL SAMPLING
OAK RIDGE GASEOUS DIFFUSION PLANT

Period 1959

Location of Point	Type of Analysis Made	No. of Samples	Concentration ($\mu c/cc \times 10^{-8}$) Plant Experience Low	High	Av.	Max. Permissible (MPC)	Av. Pl. Exp./MPC
Local Streams (Water)							
Poplar Creek	Uranium Concentration						
Upstream		52	3.7	8.7	6.2	2000	0.31%
Downstream	"	52	0.5	1.0	0.6	2000	0.03%
Clinch River							
Upstream	"	52	0.08	0.2	0.1	2000	0.005%
Downstream	"	52	0.1	0.3	0.3	2000	0.015%
Poplar Creek	Total Beta Activity						
Upstream		52	14.0	22.0	18.0	2000	0.9%
Downstream	"	52	11.0	32.0	22.0	2000	1.1%
Clinch River							
Upstream	"	52	13.0	96.0	39.0	105*	37%
Downstream	"	52	10.0	136.0	50.0	105*	48%

Normal Sampling Frequency: Continuous sampling; composited over one week.

* Measured mixture of radionuclides.

ENVIRONMENTAL SAMPLING
OAK RIDGE GASEOUS DIFFUSION PLANT

Period 1959

Location of Point	Type of Analysis Made	No. of Samples	Concentration ($\mu c/g \times 10^{-8}$) Plant Experience Low	High	Av.	Max. Permissible (MPC)
Stream Bottom (Mud)						
Poplar Creek	Uranium Concentration					
Upstream		4	400	6,900	3,200	None Specified
Downstream	"	4	1,300	4,500	2,500	
Clinch River						
Downstream	"	4	300	1,300	700	
Poplar Creek	Total Beta Activity					
Upstream		4	7,200	28,600	18,000	None Specified
Downstream	"	4	12,900	21,200	18,500	
Clinch River						
Downstream	"	4	15,800	79,200	45,500	

Normal Sampling Frequency: Grab sample, once each quarter at each location.

PRELIMINARY REPORT ON CLINCH RIVER SAMPLES
COLLECTED FEBRUARY 9-15, 1960 BY PERSONNEL OF THE
U. S. PUBLIC HEALTH SERVICE

I. General

Samples of biota, mud, and water from the Clinch River were collected by personnel of the Cooperative Studies Unit, Radiological Health Research Activities, Division of Radiological Health, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio during the period February 9-15, 1960. Personnel from the Center who participated in this sampling were Dr. A. G. Friend, Mr. A. H. Story, Mr. M. Howell, and Mr. C. Henderson. The first three of these participants named are Sanitary Engineers attached to the Radiological Health Research Activities at the Center and the latter is an Aquatic Biologist with the Research Section of Water Supply & Water Pollution Control also at the Center.

Persons contacted during this trip were: Mr. Larry Miller, Chief of the Fish & Game Department, and Mr. Jack Chance, Fish Biologist, both of TVA at Norris, Tennessee; Mr. Wilbur Kochtitzky, Mr. Milo Churchill, Mr. Ward Filgo, and Mr. Buckingham of TVA in Chattanooga, Tennessee; Mr. Swearingen, Plant Superintendent of the Chattanooga Water Treatment Plant; Mr. Ralph Sinclair, and Mr. Harold Mulligan of the Tennessee Water Pollution Control Board; Mr. Price Wilkins and Mr. Ed Manges of the Tennessee Fish & Game Department; Dr. Frank Parker, Dr. Dan Nelson, Mr. Roy Morton, Mr. Ray Richardson, and Mr. Ken Cowser of the Health Physics Section, ORNL; and Mr. John Latendresse, Mr. Cecil (Meatball) Morse, and Mr. J. P. Lyons, all the latter being commercial fishermen in this area.

II. Location of Sampling Stations and Samples Collected

A. Station 1

Station 1 was the area above Norris Dam. The water sample from Station 1 was collected from the concession stand approximately 1/4 mile north of Norris Dam. The mud sample was collected in the vicinity of Pellissippi boat dock, approximately six miles above the dam on the Clinch River arm of the reservoir. One large fish sample was collected from the mouth of the cove at the boat dock and the other two fish samples were furnished by Mr. John Latendresse. These latter fish were collected from the upper reaches of Norris Reservoir where commercial fishing was going on at the time of this trip. The minnows from Station 1 were collected from a small stream flowing into the reservoir about three miles above Norris Dam by Mr. Mulligan and Mr. Sinclair of the Water Pollution Control Board.

In the stretch of the river between Norris Dam and White Oak Creek (I would estimate about half way) a sample of filamentous algae and one live clam were collected.

B. Station 2

The water sample from Station 2 was collected from White Oak Creek about 50 feet above its point of entry into the Clinch River. Fish samples were collected from the mouth of White Oak Creek and at a point about 150 yards downstream from the mouth. Bottom mud samples were collected in the vicinity of the dam on White Oak Creek, at the mouth of White Oak Creek and from the Clinch River about 150 yards downstream from the mouth. A sample of soil was also taken from the creek bank near the mouth of White Oak Creek.

C. Station 3

The water sample collected at Station 3 was taken from the center pier of the Gallaher Bridge located near the mouth of Grassy Creek. Bottom mud samples were collected about one mile below the mouth of Poplar Creek at buoy 10.9 and about 200 yards below the point of entry of Poplar Creek into the Clinch River. Fish samples were collected just above and just below Gallaher Bridge. A medium-size eastern painted turtle was collected in the gill net just below Gallaher Bridge. We are indebted to Mr. Ed Manges of the Tennessee Fish & Game Commission for his aid in collecting the fish samples at Station 3.

D. Station 4

The water sample from Station 4 was collected on the south bank of the Clinch River at Anderson Ferry almost opposite the point where the Emory River enters the Clinch. Mud samples were collected at the mouth of the Emory River and about 1/4 mile above Anderson's Ferry in the Clinch River. Large fish from Station 4 were collected about 1/2 mile below highway 70 bridge west of Kingston. The small fish sample at Station 4 was collected at the same point as the mud samples about 1/4 mile above Anderson's Ferry.

E. Station 5

The water sample at Station 5 was collected immediately above the face of the Fort Loudon Dam. We are indebted to the Security Officers at the Dam for changing sample bottles every day, thus relieving us of the necessity of visiting this sampler daily. The mud samples from Fort Loudon Reservoir was collected about eight miles above the dam at a public picnic area. The fish samples were collected from the same area. For these fish collections we are indebted to Mr. Price Wilkins, Principal Trout Biologist of the Tennessee Fish & Game Department, who accompanied us to this area and furnished the boat and motor with which the collections were made.

F. Station 6

The water sample from Station 6 was collected from the tail race below Watts Bar Dam. The mud sample (sand) was collected about 1/2 mile below the Dam. A sample of clam shell from this same area was also collected for analysis.

G. Station 7

The water samples from Station 7 were collected by Mr. Swearingen, Plant Superintendent of the Chattanooga Water Treatment Plant. These daily samples consisted of hourly composites of both the raw intake water and the treated water. Mr. Swearingen also collected for us a sample of settled filter sludge approximately eight months old, a sample of back-wash water, and a sample of used filter sand from the Chattanooga Water Treatment Works. Mud samples were collected from the upstream face of the Chickamauga Dam and from South Chickamauga Creek about 1/4 mile from its mouth and below the heavy metals industry, the effluent of which was discharged into this creek. Fish collected at Station 7 consisted of four catfish from the vicinity of Hixson, Tennessee in the Chickamauga Reservoir. One medium size gizzard shad was collected immediately below the Chickamauga Dam and a sample of buffalo was collected from Hales Bar Dam near Shellmound, Tennessee.

In addition to the above samples three bottom mud samples were collected from Bear Creek on the Oak Ridge Reservation. A complete listing of all samples analyzed is shown in Table 1. In some instances, however, the numbers do not indicate individual samples collected during the trip but samples analyzed, e.g. an individual fish may furnish from one to seven samples when separated into component parts for analytical purposes.

III. Discussion of Results

A. Water

Gamma spectra of water samples collected at the various stations on the Clinch and Tennessee Rivers are shown in Figure 1. Radionuclide concentrations for these various samples are shown in Table 2. The predominant radioisotopes found were Ce^{144}-Pr^{144}, Ru^{106}-Rh^{106},

TABLE 1

Sample Type	Station Number								Type Totals
	1	2	3	4	5	6	7	X	
Algae bags		5						10	15
Clam (shells)	1					1			2
Crayfish	1								1
Fil. algae	1								1
Filter sand							2		2
Fish	18	6	40	38	9		16		127
Mud	1	4	4	2	1	1	2	4	19
Plankton tow	1		1	1	1				4
Rock								1	1
Sand wash H_2O							3		3
Sludge							1		1
Spinach bags		5						6	11
Snails	1								1
Tea bags		11						13	24
Turtle			1						1
Water	1	6	5	1	1	1	2		17
Station Totals	25	37	51	42	12	3	26	34	230

1 - Clinch River at Norris Dam
2 - " " " White Oak Creek
3 - " " " Grassy Creek Bridge
4 - " " " Kingston
5 - Tennessee River at Fort Loudon Dam
6 - " " " Watts Bar Dam
7 - " " " Chattanooga
X - Three different locations at Bear Creek

Cs^{137}-Ba^{137m}, Co^{60}, and Sr^{90}. Traces of Zr^{95}-Nb^{95} and Zn^{65} were indicated by these spectra. Plots of the activities of the various isotopes at the various stations are shown in Figure 2. From this plot it will be noted that the Ce^{144}-Pr^{144} and Co^{60} disappear from the water phase quite rapidly -- little activity from either of these nuclides being noted beyond Station 3. Cs^{137} also seems to disappear from the water phase quite rapidly -- no activity from this isotope being indicated below Station 4. The ruthenium and strontium, however, appear to remain in the water phase for appreciable lengths of time as indicated by the plots on Figure 2 for these elements. It is probable that this rapid reduction in concentration in the water phase is due to the uptake of Ce^{144}-Pr^{144}, Co^{60}, and Cs^{137}-Ba^{137m} by the bottom muds either due to ion exchange, to adsorption, or to precipitation.

B. Bottom Muds

Gamma spectra of bottom mud samples collected at the various stations on the Clinch and Tennessee Rivers are shown in Figure 3. Station 1 and 5 are to be considered as background. It will be seen that the same isotopes found in the water also appear in the spectra of the bottom muds with much higher concentrations. Radionuclide concentrations for these various samples are shown in Table 3. A plot showing the concentrations of the various radionuclides in the bottom muds is shown in Figure 4. The low values shown at Station 6 which were collected at Watts Bar Dam are probably due to scour in this area and also to the fact that the mud sample from this station showed very little clay content from visual inspection, the main component being sand which has very low ion exchange capacity. The high concentrations further down the river at the face of Chickamauga Dam were consequently due to the deposition of materials transported by the river or may be due to ion exchange _in situ_. Figure 5 shows gamma spectra of bottom mud samples collected from some of the tributaries flowing into the Clinch and Tennessee Rivers in the reaches under study. These streams include White Oak Creek, Bear Creek, Poplar Creek, and South Chickamauga Creek. Also shown is a spectrum of the mud samples collected from Loudon Reservoir. Corresponding nuclide concentration in the bottom muds as determined from these samples are shown in Table 4. As might be expected the nuclide concentration values reported for the sample collected from White Oak Creek are quite high with the presence of Ce^{144}-Pr^{144}, Ru^{106}-Rh^{106}, Cs^{137}-Ba^{137m}, Zr^{95}-Nb^{95}, and Co^{60} indicated. The spectra of mud samples collected from Poplar Creek also show the presence of the same nuclides as those found in the White Oak Creek samples, although the concentrations are lower by a factor of one or two orders of magnitude. Whether these isotopes found in the mud at Poplar Creek originated from White Oak Creek or whether it reflects discharge practices in the K-25 was

TABLE 2

RADIONUCLIDE CONCENTRATION IN WATER AT VARIOUS STATIONS AT CLINCH AND TENNESSEE RIVERS

Feb. 9 - 15, 1960

STATION	$Ce-Pr^{141-144}$ uuc/l	$Ru-Rh^{106}$ uuc/l	$Cs-Ba^{137}$ uuc/l	$Zr^{95}-Nb^{95}$ uuc/l	Zn^{65} uuc/l	Co^{60} uuc/l	Sr^{90}* uuc/l
1 (430)	---	---	---	---	---	---	0.5
2 (432)	985	14,300	1900	T	---	321	2825
3 (373)	625	870	115	---	---	17	19.7
4 (431)	---	890	96	T	---	T	5.8
5 (228)	---	---	---	---	---	---	0.4
6 (429)	---	110	---	T	---	T	1.5
7 (Raw) (427)	---	525	---	---	T	T	4.4
7 (Treated) (428)	---	230	---	---	---	T	3.6

* Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

ABLE 3

RADIONUCLIDE CONCENTRATIONS IN BOTTOM MUD SAMPLES FROM THE CLINCH AND TENNESSEE RIVERS

Feb. 9 - 15, 1960

SAMPLES Location	Ce^{144} uuc/kg*	Ru^{106} uuc/kg*	Cs^{137} uuc/kg*	Zr^{95} uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Ft. Loudoun Resevoir (213)	1160	---	T	70	---	---	283
Norris Dam Resevoir (202)	940	350	T	70	---	---	74
Clinch River at mouth of White Oak Creek (204)	2.32×10^6	2.44×10^6	8.75×10^6	7.6×10^4	---	5.1×10^5	9.7×10^4
Clinch River 150' below mouth of White Oak Creek (206)	5.7×10^4	1.0×10^5	3.64×10^5	4.12×10^3	---	2.1×10^4	8.6×10^3
Clinch River 300' above Gallaher Bridge (207)	2.75×10^6	3.98×10^6	3.16×10^5	2.36×10^5	---	2.5×10^5	5.0×10^3
Clinch River at mouth of Emory River (212)	1900	4450	11,000	T	---	600	900
Clinch River 1200" above Anderson Ferry (211)	1.77×10^4	4.2×10^4	8.85×10^4	1.17×10^3	---	880	260
Tennessee River below Watts Bar Dam (214)	---	T	790	T	---	---	170
Tennessee River at face of Chickamauga Dam (215)	2900	3200	6100	210	---	690	535

* Dry weight

** Sr^{90} values shown only for samples analyzed. [illegible]

'ABLE 4

RADIONUCLIDE CONCENTRATIONS IN BOTTOM MUDS OF CLINCH AND TENNESSEE RIVER TRIBUTARIES

Feb. 9 - 15, 1960

SAMPLING Location	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
White Oak Creek Dam (203)	5.02×10^6	6.64×10^7	3.79×10^7	7.32×10^6	---	2.85×10^6	1.03×10^6
Mouth of White Oak Creek ℄ (205)	1.12×10^6	2.45×10^6	9.25×10^6	1.53×10^6	---	7.65×10^5	3.59×10^5
Bear Creek at White Wing Rd. (217)	---	---	---	---	---	---	21
Ft. Loudoun (213)	---	---	T	---	---	---	295
Bear Creek (Rock) at White Wing Rd. (220)	---	---	T	---	---	---	63
Bear Creek, White Wing Rd. and Turnpike (221)	---	---	T	---	---	---	
Bear Creek (Gravel) (219)	---	---	T	T	---	---	32
Poplar Creek ℄ (208)	5.86×10^5	1.2×10^6	5.0×10^6	2.96×10^4	---	3.36×10^5	802
Poplar Creek 200 yds. up from mouth (210)	1.23×10^5	3.82×10^5	4.29×10^5	2.05×10^4	---	3.97×10^4	770
Poplar Creek 200' below K-25 fence (209)	---	---	1.2×10^5	---	---	2.5×10^5	532
S. Chickamauga Creek (216)	3700	---	---	455	---	---	331

* Dry weight

** 90

not determined at this time. From the data, however, it appears that the former premise is more dependable since activity levels are lower upstream in Poplar Creek than at the mouth. From the sample collected at Bear Creek little activity due to man-made nuclides appeared although peaks are present which indicate some activity due to decay products of both Th^{232} and U^{238}. The same may be said of the sample collected at Fort Loudon Reservoir.

It has been reported that a heavy-metals industry located on South Chickamauga Creek just above Chattanooga might be responsible for the high activity levels of Sr^{90} reported by the Basic Water Quality Network for Tennessee River water at Chattanooga. While in Chattanooga we inquired as to the activity of this industry and were told that it had discontinued operation about eight months prior to this visit. However, in order to determine if there was a reservoir of activity in the bottom muds of the South Chickamauga Creek which might be slowly released into the water, a bottom mud sample was collected about 1/4 mile from its point of confluence with the Tennessee River. The gamma spectrum of this mud sample shows little activity due to man-made nuclides; however, peaks do indicate the presence of decay products of U^{238} and Th^{232}.

C. Fish

In general when the samples were large enough they were divided into component parts consisting of flesh; bone; scales; liver; gill, heart, and thyroid; stomach, intestines, and contents; and the remaining viscera. Each of these samples was analyzed separately in order to determine the location of specific radionuclides in the body.

1. Stations 1 and 5

Gamma spectra of fish samples collected from Station 1 (Norris Reservoir) and Station 5 (Fort Loudon Reservoir) are shown in Figures 6, 7, 8, and 9. Nuclide concentrations are shown in Tables 5, 6, 7, and 8. For relative values these samples were taken as background, i.e. do not reflect any influences from the discharge of White Oak Creek to the Clinch River. It will be noted that in general slight concentrations in nuclides are reported, this activity probably being due to fallout on the water shed from weapons test.

2. Station 2

The fish collected from White Oak Creek were small and consequently it did not seem advisable to divide them into seven samples as we did for larger fish. These small fish were divided into two samples. They were gutted and the insides counted as one sample, the remainder of the fish counted as another.

.ABLE 5

RADIONUCLIDE CONCENTRATIONS IN CARP FROM STATION 1, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (400)	---	213	T	256	385	---	21
Flesh (401)	---	---	36	14	---	---	
Bone (406)	---	545	372	---	---	---	22
Liver (403)	---	T	---	---	---	---	
Intestines and Contents (404)	---	---	---	---	---	---	
Viscera (405)	---	390	T	---	---	---	
Ovaries (406)	---	167	T	---	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 6

RADIONUCLIDE CONCENTRATION IN CARP-SUCKER (QUILLBACK) FROM NORRIS RESERVOIR, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (386)	---	480	110	T	---	---	
Flesh (387)	---	320	T	---	---	---	
Bone (388)	---	440	---	70	300	---	28.5
Intestine and Contents (389)	---	T	T	---	---	---	
Liver (390)	---	T	T	---	---	---	
Viscera (391)	---	220	T	---	---	---	
Gills (392)	---	460	---	80	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN CARP FROM THE TENNESSEE RIVER AT STATION 5

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (393)	---	---	200	T	200	T	7.8
Flesh (394)	---	260	---	---	145	---	
Bones (395)	---	750	T	770	3320	T	5.5
Gills (396)	1320	440	---	70	280	T	
Liver (397)	---	950	220	100	---	---	
Intestine and Content (398)	---	720	290	---	---	T	
Viscera (399)	---	---	130	70	---	T	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

The samples collected from White Oak Creek represent three species, gizzard shad, white bass, and sauger. The gamma spectra obtained from the analyses of these fishes are found in Figure 10. Radionuclide concentrations found in these species are shown in Table 9. It is interesting to note that the activities of the gizzard shad were significantly higher than those of the white bass and sauger on a per kilogram basis. This is probably due to the fact that the gizzard shad are lower in the food chain than the game species represented by the bass and sauger; and consequently, due to their feeding habits, accumulated greater quantities of all the nuclides than did the latter.

3. Station 3

Gamma spectra of the component parts of two game species of fish, white bass and sauger, are shown in Figures 11 and 12, respectively. Corresponding nuclide concentrations are shown in Tables 10 and 11. Since these are game species of fish the nuclide concentrations are smaller than would be the case with filter and bottom feeding fish. The concentration of nuclides from the component parts of the latter type fish are shown in Tables 12, 13, and 14. Gamma spectra for these samples are shown in Figures 13, 14, and 15.

The nuclides present in the fish collected at Station 3 are identical with those found in White Oak Creek and with the water collected from White Oak Creek; however, the corresponding levels of activity are appreciably lower. The nuclides found were Ce^{144}-Pr^{144}, Ru^{106}-Rh^{106}, Cs^{137}-Ba^{137m}, Zr^{95}-Nb^{95}, Zn^{65}, Co^{60}, and Sr^{90}.

The nuclide concentrations in the carp from Station 3 presents an interesting picture. A perusal of the values shown in the Figure indicate that practically all the activity is tied up with the stomach, intestines, and content. One might speculate that this fish had probably spent most of its time in the Clinch River upstream of White Oak Creek or in one of the tributaries flowing into this area and that it had only recently moved into the area where it was caught. If this were true, then the high nuclide concentrations of ruthenium and cesium in the intestinal samples would indicate that this was taken up with the food and that the fish had not been able to assimilate and fix this in his body organs to any extent. Conversely one might say that the gizzard shad from this station had spent an appreciable length of his time in waters with relatively high nuclide concentrations.

4. Station 4

Three samples of game fish representing two species, sauger and smallmouth bass, were collected at Station 4. Gamma spectra of these samples are shown in Figures 16, 17, and 18, respectively. Nuclide concentrations are shown in Tables 15, 16, and 17.

TABLE 9

RADIONUCLIDE CONCENTRA..ONS IN FISH FROM WHITE OAK CREEK

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Gizzard Shad Structure (298)	---	43,000	15,300	T	---	3000	
Gizzard Shad Viscera (299)	---	232,000	74,000	4,500	T	10,400	
White Bass Structure (303)	---	8,900	2,900	60	710	---	56
White Bass Viscera (302)	---	20,600	3,300	140	T	640	
Sauger Structure (301)	---	3,600	1,400	---	T	---	16
Sauger Viscera (300)	---	4,150	1,700	140	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 10

RADIONUCLIDE CONCENTRATION IN WHITE BASS, STATION 3, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Flesh (317)	---	345	700	30	T	T	
Bone (318)	710	1000	T	T	---	---	665
Viscera (319)	---	T	---	---	---	---	
Liver (320)	?	?	?	T	---	---	
Intestine and Content (321)	---	2300	700				
Scales (323)	---	T	T	150	---	---	635

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 11

RADIONUCLIDE CONCENTRATION IN SAUGER FROM STATION 3, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Bones (284)	---	---	T	---	---	---	56
Flesh (285)	---	---	750	---	---	---	
Scales (286)	---	3300	900	---	---	---	430
GHT (287)	---	3300	950	---	---	---	
Liver (288)	---	---	T	---	T	---	
Viscera (289)	---	---	520	---	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 12

RADIONUCLIDE CONCENTRATION IN GIZZARD SHAD FROM CLINCH RIVER, STATION 3

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Intestine and Contents (310)	8400	28,500	16,200	200	---	180	
Liver (311)	---	4,200	1,780	140	450	---	
Flesh (312)	---	---	1,100	---	900	---	
GHT (313)	---	2,200	2,600	T	250	---	
Viscera (314)	4400	13,700	74,000	230	660	970	
Bone (315)	720	1,760	1,550	60	710	---	850
Scales (316)	---	740	470	50	110	170	1080

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 13

RADIONUCLIDE CONCENTRATIONS IN SHIPJACK HERRING FROM STATION 3, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (229)	---	210	390	---	---	---	162
Gills (230)	---	2280	1050	---	180	---	
Ovaries and Testes (231)	---	T	1200	T	---	---	
Intestine and Contents (232)	---	800	660	---	---	---	
Liver (233)	---	---	800	---	---	---	
Viscera (234)	---	820	720	---	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 14

RADIONUCLIDE CONCENTRATIONS IN CARP FROM STATION 3, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Intestine and Contents (291)	---	9400	12,800	T	---	---	
GHT (292)	---	---	T	---	---	---	
Liver (293)	---	---	---	T	---	---	
Viscera (294)	---	---	T	---	580	---	
Scales (295)	---	---	T	---	530	---	290
Bone (296)	---	T	T	---	280	---	223
Flesh (297)	---	---	432	---	270	---	51

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

Gamma spectra of carp and carp sucker from this same station are shown in Figures 19 and 20. Nuclide concentrations found on analyses from their component parts are shown in Tables 18 and 19. The same error in drawing conclusions concerning uptake by fish which has been stated for the smallmouth bass are more vividly pointed up by comparing these two samples of fish which have similar feeding habits. Here the nuclide concentrations are significantly different.

Gamma spectra of small fish samples collected at Station 4 are shown in Figure 9.

5. Station 7

A fish sample consisting of four catfish, collected from the Chickamauga Reservoir at Hixson, Tennessee, was obtained from a commercial fisherman. The gamma spectra obtained from composited component samples obtained from all these fish are shown in Figure 21 and nuclide concentrations are shown in Table 20. The results of the analyses of these fish for radioactivity are surprising since none of the man-made isotopes appear in concentrations large enough for determination by gamma spectroscopy, although the gamma spectra do indicate the presence of the decay products of Th^{232} and U^{238} in measureable quantities. Strontium-90 concentrations were determined by radiochemical means. Here again one might speculate that these fish had spent all of their life in one of the tributaries which is not effected by discharge practices of ORNL and had only recently migrated into the Tennessee River proper. Such an explanation would appear feasible provided the information we obtained from the commercial fisherman was true and these fish had been caught from the Chickamauga Reservoir on the preceding day.

Gamma spectra of a buffalo taken from Hales Bar Reservoir below Chattanooga are shown in Figure 22 and nuclide concentrations determined for these samples are shown in Table 21. With the exception of Ce^{144}-Pr^{144} and Co^{60}, all the other expected isotopes are present, some at surprisingly relative high levels.

D. Miscellaneous Aquatic Fauna

Gamma spectra of miscellaneous aquatic fauna consisting of snails, crayfish, clams, and a turtle are shown in Figure 23. Nuclide concentrations where they could be calculated are shown in Table 22. In some instances the counting geometry was not determined and consequently nuclide concentrations based on these gamma scans are not possible. However, all the samples, except the turtle, were submitted for radiochemical analyses and the results obtained for Sr^{90} are shown. It is significant to note the level of Zn^{65} found in the snail sample which was collected from a small stream flowing into Norris Reservoir, while only traces were found in those samples collected at other places.

TABLE 15

RADIONUCLIDE CONCENTRATION IN SAUGER FROM STATION 4, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Flesh (362)	---	840	490	T	---	---	
Bones (363)	---	1000	---	T	---	---	31
Intestine and Content (364)	---	2600	---	T	---	---	
Viscera (365)	300	370	T	---	185	---	

* Live weight

**Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 16

RADIONUCLIDE CONCENTRATIONS IN SMALLMOUTH BASS FROM STATION 4, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (324)	2750	950	500	17	95	180	198
Flesh (325)	---	440	600	30	63	60	
Bones (326)	---	690	190	30	63	---	33.4
Liver (327)	---	490	370	54	390	---	
Viscera (328)	---	235	270	---	T	---	
Intestine and Content (329)	---	1050	485	25	85	T	
GHT (330)	---	2150	530	30	T	120	
Ovaries (331)	---	850	410	32	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 17

RADIONUCLIDE CONCENTRATION IN SMALLMOUTH BASS, STATION 4, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Intestine and Content (338)	---	T	T	---	---	T	
GHT (339)	---	T	T	T	T	T	
Scales (340)	---	490	380	---	T	---	109
Flesh (341)	T	450	570	---	---	---	
Bone (342)	T	---	650	T	150	T	
Liver (343)	---	---	---	---	---	---	
Ovaries (344)	---	T	T	---	---	---	
Viscera (345)	---	---	---	---	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 18

RADIONUCLIDE CONCENTRATION IN CARP FROM THE TENNESSEE RIVER AT STATION 4

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg*	$Ru-Rh^{106}$ uuc/kg*	$Cs-Ba^{137}$ uuc/kg*	$Zr^{95}-Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (354)	---	---	---	---	---	---	60
Flesh (355)	---	440	460	T	---	---	
Bones (356)	---	310	T	---	---	---	41
Liver (357)	---	2600	T	41	---	---	
GHT (358)	---	700	120	20	140	---	
Intestine and Contents (359)	---	---	1000	77	145	---	
Viscera (360)	---	---	450	73	---	---	
Ovaries (361)	---	375	660	16	92	100	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 19

RADIONUCLIDE CONCENTRATIONS IN CARP SUCKER FROM STATION 4, CLINCH RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (346)	---	800	80	40	---	---	63
Flesh (347)	---	430	325	15	---	---	
Bones (348)	---	192	345	15	---	---	74
Liver (349)	---	42,000	2700	1600	7600	---	
Ovaries (350)	---	36,000	53,000	2900	8900	---	
GHT (351)	---	935	150	36	---	---	
Intestines and Content (352)	5100	30,000	17,000	146	390	770	
Viscera (353)	430	1600	435	---	90	140	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 20

RADIONUCLIDE CONCENTRATION* IN CATFISH, STATION 7, TENNESSEE RIVER

SAMPLE	$Ce\text{-}Pr^{141\text{-}144}$ uuc/kg**	$Ru\text{-}Rh^{106}$ uuc/kg**	$Cs\text{-}Ba^{137}$ uuc/kg**	$Zr^{95}\text{-}Nb^{95}$ uuc/kg**	Zn^{65} uuc/kg**	Co^{60} uuc/kg**	Sr^{90}*** uuc/kg**
Flesh (366)	---	---	---	---	---	---	
Ovaries (367)	---	---	---	---	---	---	
Bone (368)	---	---	---	---	---	---	665
Intestine and Content (369)	---	---	---	---	---	---	
Viscera (370)	---	---	---	---	---	---	
GHT (371)	---	---	---	---	---	---	
Liver (372)	---	---	---	---	---	---	

* All gamma activity appears to be associated with natural activity.

** Live weight

*** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

E. Plankton

Plankton tows were obtained at four stations, 1, 5, 3, and 4. Gamma spectra of these samples are shown in Figure 24. These samples were quite small indicating a practical absence of plankton from the river system at this time of the year and consequently the nuclide concentrations on these small samples were so minute that their spectra appear as practically normal background.

F. Filter Sand from Chattanooga

Gamma spectra of filter sand as collected, after washing, and of two wash waters, are shown in Figure 25. Corresponding nuclide concentrations for these samples are shown in Table 23. The filter of the unwashed sand showed activity due to Ce^{144}-Pr^{144}, Ru^{106}-Rh^{106}, Cs^{137}-Ba^{137m}, and Co^{60}, with a trace of Zr^{95}-Nb^{95}. In order to determine if this activity could be removed from the sand by a simple backwash procedure, the sand sample was placed in an approximately equal volume of water and stirred for about five minutes. The result of the gamma analysis of the wash water, obtained from this washing, is shown as the third spectrum in Figure 25. After this preliminary washing the sand was again resuspended in about an equal volume of water and stirred quite rapidly for approximately 20 minutes to see if attrition between sand grains would remove any activity left on the sand after the first washing. A gamma spectrum of the second wash water is shown as the last curve on Figure 25, and a final gamma spectrum of the filter sand after the two washings is shown as the second spectrum of Figure 25. A glance at this latter spectrum indicates that the activity due to ruthenium, cesium, cerium, and cobalt are very firmly attached to the sand particles and would be difficult to remove by mechanical means. The type of fixation, however, is not determined.

TABLE 21

RADIONUCLIDE CONCENTRATIONS IN BUFFALO FROM STATION 7, TENNESSEE RIVER

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*	Sr^{90}** uuc/kg*
Scales (408)	---	66	T	---	---	---	95.1
Flesh (409)	---	2600	185	---	---	---	
Bones (410)	---	1380	157	---	69	---	307.
Intestines and Content (411)	---	4400	207	---	---	---	
Liver (412)	---	1860	230	99	150	---	
Viscera (413)	---	142	T	55	110	---	
Gills (414)	---	---	T	---	---	---	

* Live weight

** Sr^{90} values shown only for samples analysed. Values obtained by radiochemical analyses.

TABLE 22

RADIONUCLIDE CONCENTRATIONS OF MISCELLANEOUS AQUATIC FAUNA FROM CLINCH AND TENNESSEE RIVERS

Feb. 9 - 15, 1960

SAMPLE	$Ce-Pr^{141-144}$ uuc/kg**	$Ru-Rh^{106}$ uuc/kg**	$Cs-Ba^{137}$ uuc/kg**	$Zr^{95}-Nb^{95}$ uuc/kg**	Zn^{65} uuc/kg**	Co^{60} uuc/kg**	Sr^{90}*** uuc/kg**
Snails from Norris Resevoir (407)	---	T	---	---	2170	---	145.
Crayfish from Norris Resevoir (421)	---	---	---	---	---	---	118.
Clam from Clinch River above White Oak Creek (222)	---	T	---	---	T	---	35.8
Turtle from Clinch River, Station 3 (227)	+*	---	+*	+*	T	---	
Clam shells from below Watts Bar Dam (224)	T	T	T	T	T	---	1070

* (+) values indicate presence of nuclides, but counting efficiency not determined.

** Live weight

*** Sr^{90} values shown only for sample analysed. Values obtained by radiochemical analyses.

TABLE 23

RADIONUCLIDE CONCENTRATIONS OF FILTER SAND AND FILTER SAND WASH WATERS

FROM THE CHATTANOOGA WATER TREATMENT PLANT

Feb. 9 - 15, 1960

SAMPLE	$Ce\text{-}Pr^{141-144}$ uuc/kg*	$Ru\text{-}Rh^{106}$ uuc/kg*	$Cs\text{-}Ba^{137}$ uuc/kg*	$Zr^{95}\text{-}Nb^{95}$ uuc/kg*	Zn^{65} uuc/kg*	Co^{60} uuc/kg*
Unwashed Filter Sand (226)	330*	5700*	730*	T	---	100*
Twice Washed Filter Sand (384)	197*	2200*	370*	6*	32*	88*
First Wash Water residue (385)	14,400**	125**	34**	0.8**	---	---
Second Wash Water residue (426)	26**	653**	79**	---	4 **	T

* Dry weight

** uuc/liter

April 13, 1960

COOPERATIVE FISH STUDIES BY ORNL AND TVA
(March 23 - April 1, 1960)

These studies were made to determine the feasibility of more intensive fisheries investigations on the Clinch River. Fortunately, the TVA Fish and Game Branch in Norris was able to cooperate. They furnished two men and all equipment used during these operations.

The specific objectives of this study were: (1) to compare relative fish catching ability of hoop nets and fish baskets; (2) to determine species of fish which may be caught by these types of fishing gear; (3) to obtain an estimate of gross gamma activity of fish caught from Clinch River Mile 21.7 to 24.4.

One hundred fifteen fish (Table I) representing 16 species were caught. The species caught are comparable to those obtained by rotenone for Knobf's analyses (ORNL 1031) and are probably the most common species in this reach of the Clinch River. The hoop nets were more effective than the baskets with regard to the numbers of fish and numbers of species caught (Table II).

Gross gamma activity was determined by placing the whole fish in a gamma scintillation detector with a 3 inch crystal. The background for this counter varied from 250-270 cpm. Net counts for each fish are listed in Table I. Fish are being obtained from Douglas Reservoir which will make it possible to evaluate the gross gamma activity of fish which are slightly over background.

These preliminary operations form the basis for a study of fish movements in the Clinch River which will be conducted this summer. If the population or any segment of it should prove to be relatively stable with respect to geographic location, it will be possible to estimate fish populations. Length and weight data will be taken routinely which will enable us to make age and growth studies of each species.

Table I. Cooperative Fish Studies by ORNL and TVA. List of Fish Caught March 23 - April 1, 1960; Clinch River Mile 21.7-24.4.

	WEIGHT (gm)	LENGTH (mm)	NET CPM
CLUPEIDAE			
Dorosoma cepedianum (LeSueur) (Gizzard Shad)	307	318	77
Alosa chrysochloris (Rafinesque) (River Herring)	177	289	-12
HIODONTIDAE			
Hiodon selenops LeSueur (Mooneye)	90	223	26
	113	242	69
CATOSTOMIDAE			
Ictiobus bubalus (Rafinesque) (Smallmouth Buffalofish)	1123	435	1970*
	994	426	59
	912	421	37*
	761	376	278
	851	395	137
Moxostoma erythrurum (Rafinesque) (Golden Redhorse)	441	343	48
	196	261	50
	964	484	77
	442	350	5
	334	323	-12
	264	290	20
	73	197	20
CYPRINIDAE			
Cyprinus carpio Linneaus (Carp)	520	360	469
ICTALURIDAE			
Ictalurus punctatus (Rafinesque) (Channel Catfish)	946	459	514
	103	231	888*
	149	264	68
	128	255	17*
	72	216	60
Ictalurus natalis (LeSueur) (Yellow Bullhead)	275	269	88
SERRANIDAE			
Roccus chrysops (Rafinesque) (White Bass)	53	175	-8
	370	301	209*
	311	284	62
	43	164	6
	70	182	135
	651	357	142
	717	380	158
	621	360	141
	536	350	113

Table I. (Continued)

Species	WEIGHT (gm)	LENGTH (mm)	NET CPM
Roccus chrysops (Rafinesque) (White Bass)	221	265	93
	60	175	123
	528	330	155
	527	350	157
	596	343	150
	830	390	179
	904	377	178
	600	340	93
	767	380	98
	472	328	117
	480	337	96
	445	320	60
	536	330	70
	597	360	50
	441	318	85
	412	295	50
	460	327	52
	704	377	230
	537	357	60
	750	362	125
	532	337	98
	446	328	90
	297	283	57
	433	318	106
	345	294	41
	376	310	32*
	533	352	126
	267	280	42
	275	280	80
	450	318	87
CENTRARCHIDAE			
Micropterus salmoides (Lacepede) (Largemouth Bass)	639	340	125
Pomoxis nigromaculatus (LeSueur) (Black Crappie)	132	210	154
	164	232	69
	184	243	53
Pomoxis annularis (Rafinesque) (White Crappie)	151	230	10
	329	270	60
	110	206	41
	178	248	191
	230	255	148
	134	220	20*
	67	179	104
	158	235	53
	178	238	63
	180	247	19
	196	245	52
	158	233	1007
	148	233	42
	121	220	1138*
	106	205	-2
	98	211	117

Table I. (Continued)

	WEIGHT (gm)	LENGTH (mm)	NET CPM
Ambloplites rupestris (Rafinesque) (Rockbass)	246	223	89
	184	212	77
	195	225	14
Lepomis macrochirus Rafinesque (Bluegill)	139	190	1515
	82	165	85
	38	128	26
	111	177	1637*
	46	138	42
	97	172	84*
PERCIDAE			
Stizostedion canadense (Smith) (Sauger)	461	384	84
	946	459	514*
	429	365	215
	265	311	317
	328	334	99
	263	316	41
	152	266	18*
	121	257	60
SCIAENIDAE			
Aplodinotus grunniens Rafinesque (Freshwater Drum)	159	243	107
	158	246	14
	148	260	5
	187	277	-2
	132	237	46
	194	260	46
	188	270	52
	143	243	32
	135	230	13
	108	222	39

* Submitted for radioanalysis (flesh, bone, liver).

Table II. Cooperative Fish Studies by ORNL and TVA. Summary of net and basket catches March 23 - April 1, 1960

	Net	Basket	Total
Gizzard Shad	1	0	1
River Herring	1	0	1
Mooneye	4	0	4
Smallmouth Buffalofish	7*	0	7
Golden Redhorse	4	3	7
Carp	1	0	1
Channel Catfish	5	0	5
Yellow Bullhead	0	1	1
White Bass	35	5*	40
Largemouth Bass	1	0	1
Black Crappie	1	2	3
White Crappie	3	13	16
Rockbass	2	1	3
Bluegill	1	5	6
Sauger	3*	6	9
Drum	10	0	10
Totals	79	36	115

* 2 Buffalofish, 1 White Bass, 1 Sauger not measured and counted.

Table 3. Fish obtained from Douglas Reservoir by TVA Fish and Game Branch, April 18-20, 1960.

	Length (mm)	Weight (gm)	Net CPM
Pilodictis olivaris Flathead Catfish	449	1063	43
White Bass	225	143	7
" "	221	115	21
" "	241	162	2
" "	233	134	5
Black Crappie	192	101	-10
White Crappie	200	105	4
Bluegill	146	51	- 8
"	172	84	- 1
"	165	82	36
"	179	101	28
"	170	90	21
"	158	67	16
Sauger	322	294	28
"	332	329	20
"	324	305	36
		Background	261

Percentages of Cesium, Cobalt, Strontium, and Zirconium-Niobium Sorbed by Clays

(Tables IV, V, VI, and VII from Memorandum Report by A. Sorathesn and G. Bruscia to E. G. Struxness, Dated April 27, 1960)

Table IV. Per Cent of CESIUM Sorbed by Clays

Standard Clays	Contact Time	% Activity Sorbed pH 6	% Activity Sorbed pH 9	K_d pH 6	K_d pH 9	Weight of Clay Used per ml of Master Solution
	1 hr	89.99±.25	90.48±.25	26,965	28,522	0.1 gm/300 ml
ILLITE	3 days	87.92±.23	98.60±.23	141,010	217,815	
	7 days	98.39±.23	98.56±.23	183,402	205,014	
	1 hr	74.23±.28	93.19±.28	2,880	13,691	0.1 gm/100 ml
KAOLINITE	3 days	73.96±.25	62.35±.27	2,840	1,656	
	7 days	68.47±.25	51.20±.44	2,171	1,049	
	1 hr	61.20±.34	58.26±.35	1,577	1,396	0.1 gm/100 ml
MONTMORILL-	3 days	55.14±.34	56.16±.35	1,229	1,281	
ONITE	7 days	49.95±.45	50.54±.45	998	1,022	
	1 hr	96.63±.25	95.77±.42	1,433	1,132	1 gm/50 ml
VERMICU-	2 days	99.41±.24	99.64±.24	8,432	14,087	
LITE	8 days	99.60±.24	99.76±.24	12,423	21,155	
	1 hr	53.75±.42	61.31±.37	2,326	3,169	0.1 gm/200 ml
RIVER	3 days	96.17±.25	96.16±.25	50,152	50,152	
SEDIMENT	7 days	97.78±.24	97.64±.24	88,048	82,769	

Table V. Per Cent of COBALT-60 Sorbed by Clays

Standard Clays	Contact Time	% Activity Sorbed pH 6	% Activity Sorbed pH 9	K_d pH 6	K_d pH 9	0.1 gram of Clay Per ml of Master Solution
ILLITE	1 hr	28.98±.52	78.04±.19	408	3,554	0.1 gm/100 ml
	3 days	85.49±.37	94.65±.35	5,891	17,706	
	7 days	86.43±.37	95.94±.35	6,372	23,624	
KAOLINITE	1 hr	63.91±.24	69.17±.22	3,541	4,486	0.1 gm/300 ml
	3 days	71.54±.21	51.51±.29	5,028	2,124	
	7 days	60.92±.25	46.58±.32	3,117	1,744	
MONTMORILL-ONITE	1 hr	69.70±.21	56.38±.26	2,301	1,293	0.1 gm/100 ml
	3 days	63.91±.46	45.68±.60	1,771	841	
	7 days	62.36±.46	45.37±.60	1,657	831	
VERMICU-LITE	1 hr	70.63±.21	72.87±.21	120	134	1 gm/50 ml
	2 days	98.63±.16	84.62±.18	3,606	275	
	8 days	98.96±.16	89.80±.18	4,737	440	
RIVER SEDIMENT	1 hr	46.44±.33	71.91±.22	1,734	5,120	0.1 gm/200 ml
	3 days	93.34±.17	82.38±.19	28,017	9,354	
	7 days	97.28±.17	85.12±.18	71,567	11,445	

Above results were calculated from Centrifuged Master Solution.

Table VI. Per Cent of STRONTIUM-85 Sorbed by Clays

Standard Clays	Contact Time	% Activity Sorbed		K_d		0.1 gram of Clay per ml of Master Solution
		pH 6	pH 9	pH 6	pH 9	
	1 hr	23.42±.62	31.67±.45	306	316	0.1 gm/100 ml
ILLITE	3 days	26.69±.54	41.05±.34	364	696	
	7 days	26.88±.54	43.17±.33	368	760	
	1 hour	62.77±.25	71.24±.22	3,372	4,954	0.1 gm/200 ml
KAOLINITE	3 days	67.49±.23	68.55±.23	4,152	4,358	
	7 days	66.435±.24	66.28±.24	3,959	3,930	
	1 hr	70.85±.20	71.88±.20	2,430	2,555	0.1 gm/100 ml
MONTMORILL-	3 days	66.88±.21	68.65±.21	2,019	2,189	
ONITE	7 days	67.21±.21	68.67±.21	2,059	2,163	
	1 hr	77.45±.22	67.14±.26	172	102	1 gm/50 ml
VERMICU-	2 days	96.95±.19	96.46±.19	1,590	1,364	
LITE	8 days	97.33±.19	98.73±.19	1,821	3,874	
	1 hr	21.42±.78	24.79±.67	545	659	0.1 gm/200 ml
RIVER	3 days	45.79±.36	63.87±.26	1,690	3,537	
SEDIMENT	7 days	41.83±.39	66.80±.25	1,438	4,024	

Table VII. Per Cent ZIRCONIUM-NIOBIUM 95 Sorbed by Clays

Clays	Contact Time	% Activity Sorbed		K_d		0.1 gm of Clay Per ml of Master Solution
		pH 6	pH 9	pH 6	pH 9	
	1 hr	83.62±.25	75.99±.27	15,310	9,497	0.1 gm/300 ml
ILLITE	3 days	90.39±.23	83.92±.30	28,241	15,659	
	7 days	94.05±.22	89.08±.23	47,437	24,470	
	1 hr	89.18±.23	81.73±.25	24,735	13,423	0.1 gm/300 ml
KAOLINITE	3 days	94.00±.22	87.03±.24	46,973	20,121	
	7 days	94.93±.22	85.82±.24	56,158	18,161	
	1 hr	14.45±1.16	26.28±.63	169	356	0.1 gm/100 ml
MONTMORILL-	3 days	28.74±.57	37.90±.43	403	610	
ONITE	7 days	35.24±.46	42.07±.39	544	726	
	1 hr	62.83±.32	54.37±.37	3,380	2,383	0.1 gm/200 ml
RIVER	3 days	82.69±.25	75.55±.27	9,554	6,181	
SEDIMENT	7 days	86.56±.24	79.94±.25	12,886	7,970	

The above results were calculated from counts/ml of Zr-Nb.
Master Solution - well mixed and stirred but not centrifuged.

SEDIMENT TRANSPORT AND RELATED DATA

By F. L. Parker

Table 1. Average Sediment in Clinch River at Oak Ridge Water Intake For 1955-1959

Month	Sediment (ppm)	Month	Sediment (ppm)
Jan. -------------	44 ± 45	July -------------	16 ± 20
Feb. -------------	49 ± 26	Aug. -------------	14 ± 9
Mar. -------------	31 ± 8	Sept. ------------	17 ± 17
Apr. -------------	35 ± 13	Oct. -------------	12 ± 5
May --------------	23 ± 12	Nov. -------------	29 ± 30
June -------------	22 ± 14	Dec. -------------	29 ± 11

Table 2. Sediment Transport in Clinch River at Oak Ridge Water Intake

Year	Sediment (tons/year)
1955 --------------------------	72,100
1956 --------------------------	68,200
1957 --------------------------	247,000
1958 --------------------------	111,800
1959 --------------------------	142,900

Table 3. Activity Passing Center's Ferry as a Function of Season*

	Discharge (cfs)	Sediment (ppm)	Activity (x 10^8) ($\frac{\mu c}{cc}$)
1956			
Fall	4,920	24	9
1957			
Winter	10,180	61	5
Spring	2,980	22	8
Summer	3,440	28	8
Fall	8,840	47	6
1958			
Winter	3,820	31	7
Spring	6,220	25	13
Summer	6,130	11	4

*Results determined from data of Applied Health Physics Section, Health Physics Division.

Table 4. Activity Passing Center's Ferry 1957-1958*

Isotope	Percentage
Co^{60}	7
$Zr\text{-}Nb^{95}$	3
Cs^{137}	13
Ru^{106}	23
Ce^{144}	13
Sr^{90}	41

*Results determined from data of Applied Health Physics Section, Health Physics Division.

Table 5. Activity Associated with Silt at Center's Ferry, 1957-1958*

Isotope	Percentage
Co^{60}	25
$Zr\text{-}Nb^{95}$	29
Cs^{137}	67
Ru^{106}	14
Ce^{144}	22
Sr^{90}	5
Average of Total Discharge	20

*Results determined from data of Applied Health Physics Section, Health Physics Division.